

Scale-Up of Novel Li-Conducting Halide Solid State Battery Electrolyte

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Overview

Timeline

Start date: December 2021
End Date: November 2024

Budget

Total: \$2.4M/3yr
DOE: \$1.2M
Cost share: \$1.2M (50%)

Partners

Saint Gobain

Barriers

Life

- Li metal anode is not compatible with halide SSB electrolytes

Performance

- Cathode thickness must be increased to enable high energy density for halide cells

Relevance

Impact

- High-performance, low-cost, easily-processed solid state battery
- Safe failure when exposed to moisture
- New fabrication approach for US battery manufacturing

Objectives

- Develop a halide battery prototype with thick cathode and Li metal
- Demonstrate halide battery at pouch cell level, using scalable processes

Milestones

Q2FY22 (Complete) Halide powder prepared by SG and characterized at LBNL

Q3FY22 (On track) Electrolyte prepared by tape casting; 40cm² area with thickness less than 100 μ m

Q4FY22 (In progress) Assessment of halide/cathode reactivity complete

Q1FY23 (In progress) Assessment of halide/processing materials reactivity complete

Q1FY23 (In progress) Prepare >5cm² area electrolyte <40 μ m and cathode >100 μ m thick; density of electrolyte >98%; conductivity of electrolyte measured with target of >1mS/cm

Q1FY23 (G/NG) Halide and primary cathode candidate are compatible.

Approach

Cell materials

- Assess compatibility of halide with cathode active materials and anode secondary electrolytes (SSE-A)
- Utilize advanced synchrotron characterization techniques

Processing

- Tape casting thin electrolyte and thick cathode; select solvents and binders to be compatible with halide
- Scalable processes for anode secondary electrolyte

Scale-up

- Demonstrate processing of layers to >40cm² size
- Demonstrate pouch-size cell

Summary

Halide advantages:

- high conductivity, good oxidation stability
- processing in dry air; toxic gas not formed by water reaction

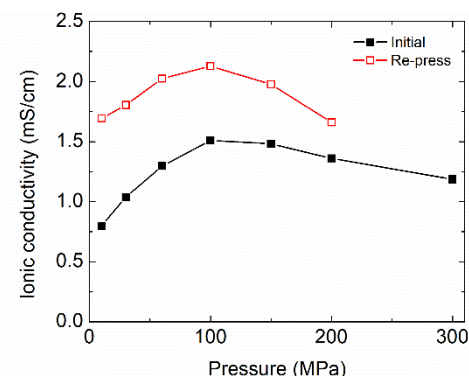
Halide challenges:

- Not stable in contact with Li metal
- High pressure needed for cell formation, possibly during cycling

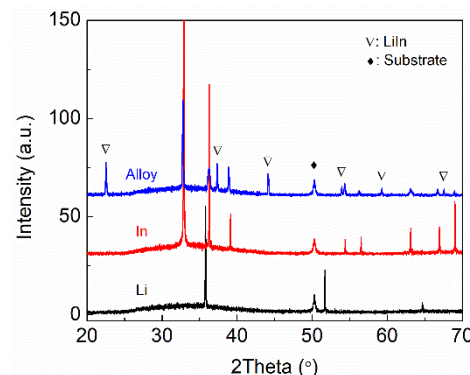
Progress:

- Halide composition with good high-voltage stability identified
- Established protocol for assembling and testing symmetric and full cells
- Cells with LiIn anode demonstrate good cathode performance

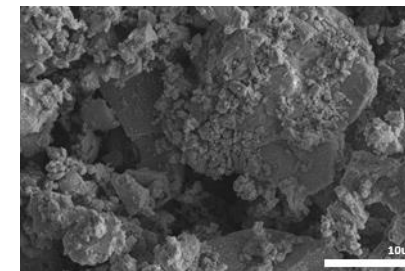
Technical Results



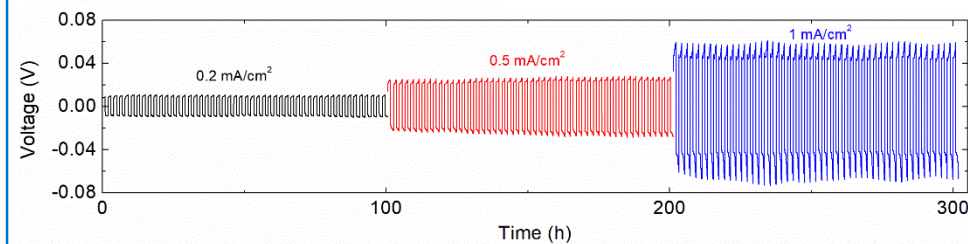
- Steel electrode is used as ion-blocking electrode for ionic conductivity measurement
- 2.1 mS/cm under 100 MPa pressure at room temperature
- Ionic conductivity is pressure-dependent, but not linear with pressure
- Formation of Li/In alloy (with excess In metal) demonstrated by XRD



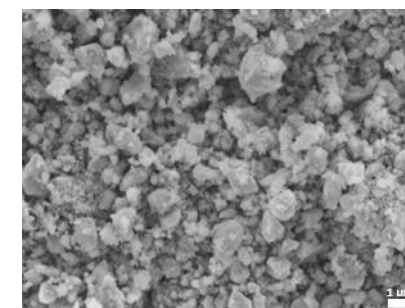
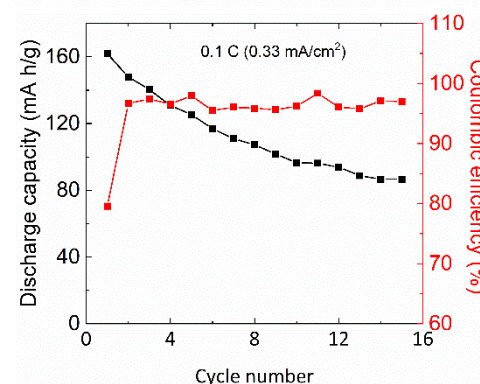
- Particle size reduction in progress at SG
- G2.2 size reduced from 10-20 μ m to 1-2 μ m, further optimization in progress



Un-milled G2.2



- Li/In|halide|Li/In symmetric cell cycles well at current density up to 1 mA/cm² at room temperature
- Overpotential slightly increases during each period at high current density
- Initial charge capacity reaches 203 mAh/g and discharge capacity reaches 162 mAh/g at room temperature with un-milled halide powder. CAM loading is 12 mg/cm²
- Capacity fades quickly – mismatch between CAM and halide particle sizes



Milled G2.2

Collaboration

Saint Gobain - cost share partner

- halide composition, halide powder synthesis, cost analysis

Remaining Challenges

- Identify compatible cathode, binder, and solvent materials
- Identify SSE-A that is compatible with halide and Li metal
- Demonstrate Li metal anode
- Reduce pressure required during cycling
- Halide cells must be scaled up to commercially-relevant cell size

Proposed Future Research

- SEM, XRD, and synchrotron studies of cathode/halide, SSE-A/halide, and Li/SSE-A interfaces
- Develop tape casting slurry recipes for thin electrolyte and thick cathode
- Select SSE-A candidates based on compatibility with Li metal, conductivity, stability window, and processability
- Synthesize and assess SSE-A candidates in full cells
- Test coin and pouch cells with pellet and tape-cast electrolytes

Any proposed future work is subject to change based on funding levels